DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

AUG 1 2002

FROM: HQ AFCESA/CESC
139 Barnes Drive, Suite 1
Tyndall AFB FL 32403-5319

SUBJECT: **Engineering Technical Letter (ETL) 02-1: Design of Drainage Structures for Heavy Aircraft Loading**

1. Purpose. This ETL establishes design parameters for airfield drainage structures that may be subjected to loads by future heavy aircraft.

2. Application: All Air Force installations supporting flight operations.

2.1. Authority: Unified Facilities Criteria (UFC) 3-260-01, *Airfield and Heliport Planning and Design*.

2.2. Coordination: Major command (MAJCOM) pavement engineers.

2.3. Effective Date: Immediately.

2.4. Ultimate Recipients:

- MAJCOM pavement engineers.
- Base civil engineers (BCE), Rapid Engineers Deployable – Heavy Operations Repair Squadron Engineers (RED HORSE), and other Air Force units responsible for the design, construction, maintenance, and repair of Air Force facilities.
- U.S. Army Corps of Engineers (USACE) and Navy offices responsible for Air Force design and construction.

3. Referenced Publications:

- UFC 3-260-01, *Airfield and Heliport Planning and Design*
- Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5320-6D, *Airport Pavement Design and Evaluation*, 7 July 1995

4. Acronyms and Terms:

AC	- Advisory Circular
BCE	- base civil engineer
ETL	- Engineering Technical Letter
FAA	- Federal Aviation Administration
g	- acceleration of gravity (free-fall)
kip	- 1,000-pound load (kilopound)
m	- meter
MAJCOM	- major command

RED HORSE	- Rapid Engineers Deployable – Heavy Operations Repair Squadron Engineers
USACE	- U.S. Army Corps of Engineers

5. Background. Airfield drainage structures such as culverts and bridges are designed to support the projected mission of an Air Force base. As a base's mission and mission aircraft change, the loads on airfield drainage structures also change. Information concerning the landing gear arrangement of future heavy aircraft, whether military or civilian, is often speculative. Future heavy aircraft may increase point loadings on some structures (e.g., manhole covers), while on other structures the entire aircraft weight may be imposed on a deck span, pier, or footing (e.g., overpasses). Strengthening of drainage structures after the initial construction may prove to be extremely difficult, costly, and time consuming.

6. Recommended Design Parameters.

6.1. Structural Considerations. For many drainage structures, the design load is highly dependent upon the aircraft gear configuration. **While the exact gear configuration of future heavy aircraft is unknown, three basic gear configurations will be used to design for future heavy loads: Type A – Bicycle; Type B – Tricycle; and Type C – Tricycle.** The three basic gear configurations for future heavy aircraft come from Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5320-6D, *Airport Pavement Design and Evaluation*. For a given aircraft gross weight, each of the three basic gear configurations will be used in the design of each drainage component. Then, for each drainage component, the basic gear configuration that results in the most conservative design will be selected as the design gear configuration for that component. For purposes of design, each of the three basic configurations contains two wheel groups of eight wheels each (sixteen wheels per aircraft). Each wheel group occupies an area of 6 meters by either 1.8 meters or 2.4 meters (20 feet by either 6 feet or 8 feet), with each wheel group supporting one-half of the aircraft gross weight. Wheel prints are uniformly spaced within each of the respective wheel groups. Nose gears are not considered in the design, except as they occur in the static load.

6.1.1. Type A – Bicycle. The Type A – Bicycle configuration consists of two wheel groups located along a single line parallel to the primary aircraft axis (i.e., parallel to the line of travel), but with the major axis of each wheel group oriented perpendicular to the primary aircraft axis.

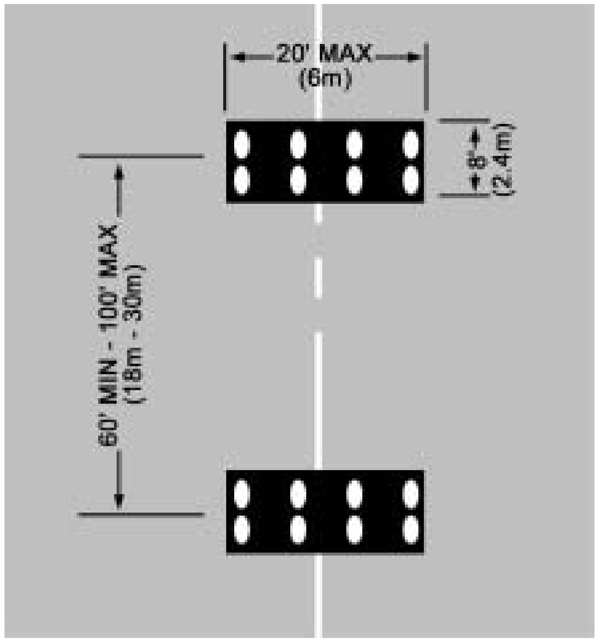

Figure 1. Type A – Bicycle Gear Configuration

6.1.2. Type B – Tricycle. The Type B – Tricycle configuration includes a nose gear, and has wheel groups whose major axes are coincident and perpendicular to the major aircraft axis.

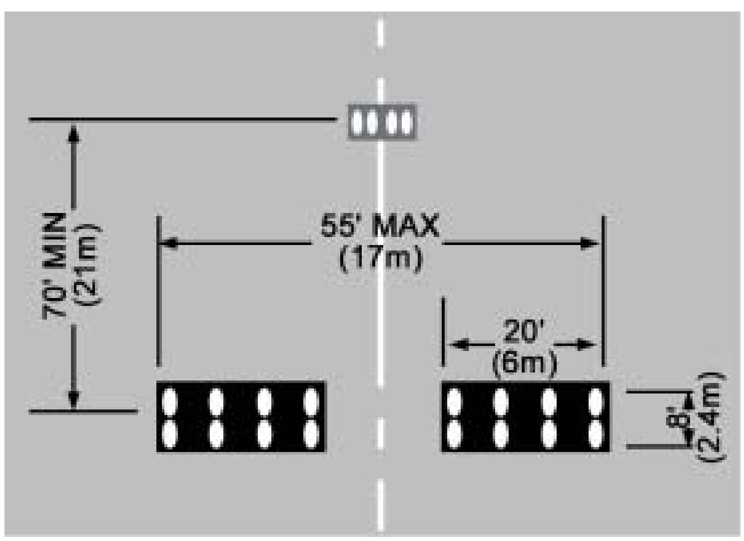

Figure 2. Type B – Tricycle Gear Configuration

6.1.3. Type C – Tricycle. The Type C – Tricycle configuration includes a nose gear, and has wheel groups whose major axes are parallel to, and equidistant from, the principal aircraft axis.

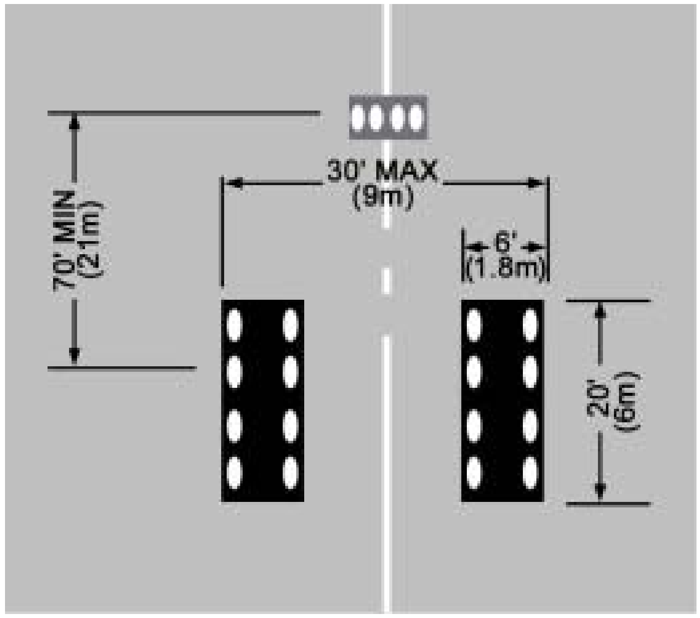

Figure 3. Type C – Tricycle Gear Configuration

6.2. Foundation Design. Foundation design will vary with soil type and depth. No departure from accepted methodology is anticipated, except that for shallow structures, such as inlets and culverts, the concentrated loads may require heavier and wider spread footings than those presently provided by the structural standards in current use. For buried structures, such as culverts, the following guidance from FAA AC 150/5320-6D is recommended:

6.2.1. When the depth of fill is less than 0.6 meter (2 feet), the wheel loads will be treated as concentrated loads.

6.2.2. When the depth of fill is 0.6 meter or more, wheel loads will be considered as uniformly distributed over a square with sides equal to 1.75 times the depth of the fill. When such areas from several concentrations overlap, the total load will be uniformly distributed over the area defined by the outside limits of the individual areas, but the total width of distribution will not exceed the total width of the supporting slab.

6.3. Loads. All loads discussed in this ETL are to be considered as dead load plus live loads. The design of structures subject to direct wheel loads should also anticipate braking loads as high as 0.7 g (for no-slip brakes).

6.4. Direct Loading. Decks and covers subject to direct heavy aircraft loading, such as manhole covers, inlet grates, utility tunnel roofs, and bridges, should be designed for the following loadings:

6.4.1. Manhole covers for 450-kilonewton (100-kip) wheel loads, with tire pressure of 1.72 megapascals (250 pounds per square inch).

6.4.2. For spans of 0.6 meter or less in the least direction, apply a uniform live load of 1.72 megapascals.

6.4.3. For spans greater than 0.6 meter in the least direction, the design will be based on the number of wheels that will fit the span. Wheel loads of 220 to 330 kilonewtons (50 to 75 kip) should be considered.

6.4.4. For structures that will be required to support both in-line and directional traffic lanes, such as diagonal taxiways or apron taxi routes, load transfer at expansion joints will not be considered in the design process. However, if specific knowledge about the long-term load transfer characteristics of a particular feature supports the use of load transfer in the design of a particular drainage structure, then an exception is allowed and load transfer will be considered.

7. Point of Contact. Recommendations for improvements to this ETL are encouraged and should be furnished to: HQ AFCESA/CESC, 139 Barnes Drive, Suite 1, Tyndall AFB, FL 32408-5319, Attention: Mr. James Greene, DSN 523-6334, commercial (850) 283-6334, FAX DSN 523-6219, Internet james.greene@tyndall.af.mil.

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